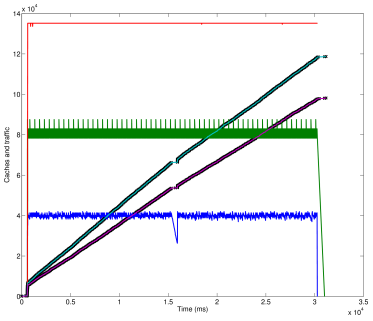
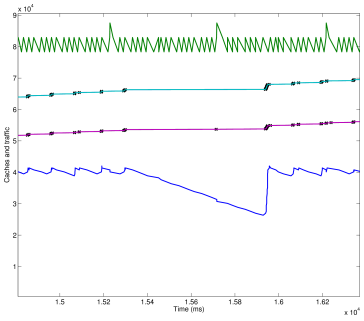
Experimentation: Determining audio buffer size from LAN-WLAN vertical handover delay

Cache behavior examples

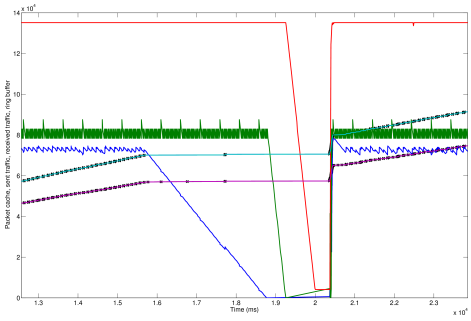
The following presents cache behavior in two example cases, the left being an ideal handover situation with a closeup, and the right one being a worst-case situation, where a buffer underrun occurs. Horizontal lines represent the packet cache sizes in bytes. The lowest line (blue) is the packet cache, the middle line (green) is the decoded buffer, and the top line (red) is the OSS / hardware buffer. The diagonal lines represent the sequence numbers of received (cyan) and sent (magenta) packets respectively, they index numbers are scaled to fit in the same image area.



Ideal case



Ideal case closeup

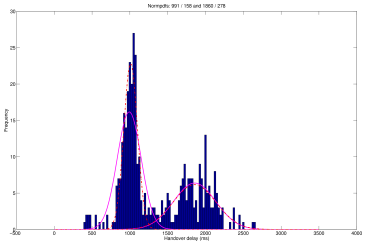


Worst-case with underrun

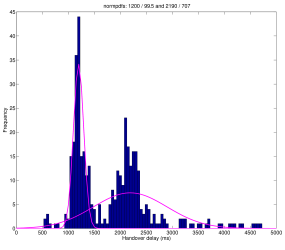
Delay distributions

Traffic delay from the handover is roughly divided between 0.5 and 2.5 seconds, but this measure does not give the full application-experienced delay in the media stream. As visible from the worst-case detail above, an individual packet is received in the middle of the gap, but the delay extends beyond it. The actual stream delay can be described as a combination of the two longest delays. 95% of the delays are in the range of 1.05 to 3.24 seconds.

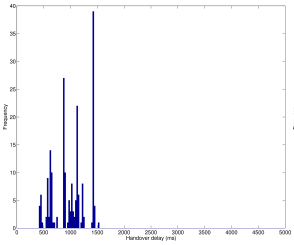
The distributions on the left are acquired with playback status messages sent individually. If they are sent coupled with new stream packet requests, the distributions are sparser, but 95% of the delays are in the same general range of 0.74 to 3.4 seconds.



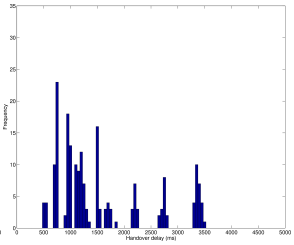
Traffic delay with approximating normpdfs



Packet cache delay (2 segments)



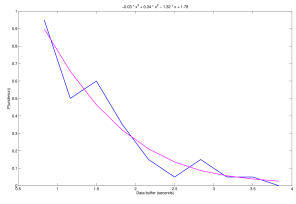
Traffic delay w/o status packets

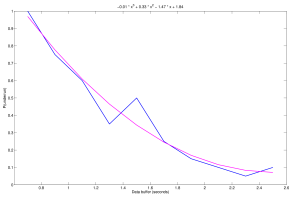


Cache delay w/o status packets

Underrun probability

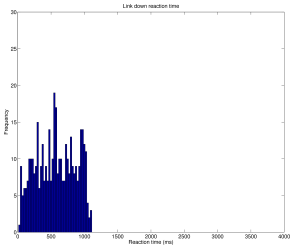
The delay described above gives a certain probability of a buffer underrun happening during the streaming. Underrun probability in the graphs below is presented for 192kbps and 320kbps streams both. Note that the underrun probability flattens to near zero after the 3 second mark, as expected from the delay distributions. Without status packets, the underrun probability curve is similar, but flattens to zero faster.



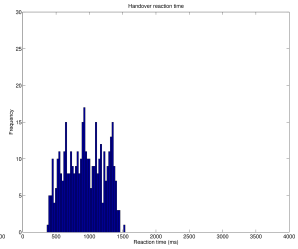


Reaction time

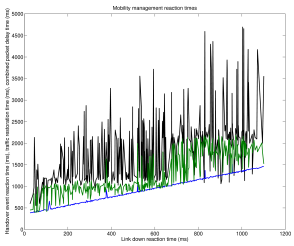
Reaction time in this context is defined as the time it takes from the last successfully recieved packet for the distinct phases to happen in the handover. The LINK_DOWN and HANOVER events are received from the mobility management, the handover event coming almost diligently 350 milliseconds after the link down event. Other graphs represent the combination of the events to the next successfully received packet and the media packet delay (2 segments). The combined reaction time graph in the very right is the result from embedding the status packets to the packet requests, which reduces the number of received packets.

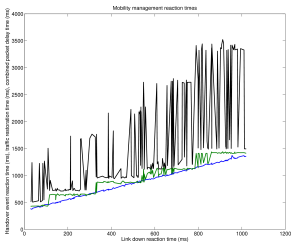


Link down reaction time



Handover event reaction time





Reaction times, traffic (green), packet (black) for status packets and w/o

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